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RECENT USSR WORK ON THE ONTOGENESIS, MODIFICATION, AND SELECTION OF MICROORGANISMS

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[Comment: The following is taken from part of a critical review of Issue 1 of Trudy Insitituta Mikrobiologii (Works of the Institute of Microbiology), Academy of Sciences USSR, 1951. A list of additional articles appearing in the issue is appended by the authors.]

In 1951, the first volume (Issue 1) of a new periodical, Trudy Insitituta Mikrobiologii, was published. This volume contains an article by N. D. Yerusalimskiy entitled "Problems of the Ontogenesis of Bacteria and Ways Toward Solution of These Problems." Yerusalimskiy regards the physiological processes taking place in living bacterial cells as the principal cause which brings about distinguishing qualitative characteristics that are typical for the ontogenesis of the bacteria in question. Specifically, these processes determine the successive stages of development of bacterial cells, i.e., stages the occurrence of which depends on definite conditions. Passing through these stages leads to qualitatively new states and involves functional and morphological changes on the part of bacteria.

The analysis of these stages (the so-called ontogenetic analysis) is likened by Yerusalimskiy to stage analysis as applied by Lysenko to flowering plants. One must conclude that transition through different stages is common to all organisms. The nature of these stages (and consequently the type of stage analysis that would be applied to any particular kind of organisms, including bacteria) depends on the specific type of metabolism and other conditions of development which affect the organisms subjected to investigation. Yerusalimskiy correctly emphasizes the difficulties which are connected with this approach and which are due to our inadequate knowledge of the stages that are essential for the development of microorganisms.

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Nevertheless, he cites several examples which illustrate stage analysis as applied to some bacteria, e.g., the analysis of spore formation by butyric acid bacteria. In this analysis, he demonstrates that formation of spores in the cases of butyric acid bacteria is a two-stage process. To acquire the ability to form spores, the bacteria must develop in a medium which completely satisfies their requirements in the spore stage. However, the bacteria, although they have acquired the ability to transform into spores, do not undergo this change unless their conditions of existence have changed. In order that they may actually transform into spores, a shortage of nitrogen in the nutrient medium and accumulation of products of metabolism in it are necessary.

Yerusalimskiy also demonstrates the essential points of stage development by the example of acetone-butyl alcohol bacteria. A physiologically young culture of this microorganism is incapable of lowering the acidity of the medium by converting excess acid into neutral substances. However, after passing through a certain stage of its development, the culture acquires the capacity of exerting this action, and thus is able to undergo normal development that includes spore formation. To pass through the stage in question, the culture requires that the nutrient medium have a definite pH and a somewhat lowered content of nitrogen. On the other hand, an increased demand for nitrogen on the part of the culture arises in the following stage. As far as the pH of the medium in this stage is concerned, the culture acquires the ability to regulate it by transforming a part of the acid into neutral substances.

The examples mentioned above prove that a good knowledge of the physiology of a microorganism permits one to outline clearly the stage modifications which will occur at various times in its life activity, and thereby to determine the moving forces behind the ontogenesis of the microorganism as well as the characteristics of its ontogenetic cycle. Without this knowledge, a correct solution of problems of bacterial ontogenesis is impossible. An arbitrary interpretation of morphological data may easily lead to entirely fantastic assumptions which have nothing in common with actual relationships governing the interchange of ontogenetic phases.

In addition to presenting the subject matter outlined above, Yerusalimskiy touches on several other aspects of the problems involved. What is more important, he indicates possible ways for the solution of these problems.

The article "Filterable Forms of Bacteria" by G. P. Kalina, which is also published in the first issue of Trudy Instituta Mikrobiologii, deals with noncellular phases of the existence of microorganisms. The author restricts himself to an exposition of the present status of the problem [without going into the history of scientific work in this field]. At present, the fact that filterable phases form in the cultures of various bacteria must be regarded as definitely established. However, the characteristic properties of filterable forms have not yet been studied adequately. Nothing is known about their biochemical composition or morphology. The methods for their detection are still imperfect and experiments on their cultivation cannot always be reproduced.

The feeder [kormilki murray] method of cultivating filterable forms, proposed in 1932 by Sukner and Wol'fertz, was regarded as the best. Kalina mentions a number of shortcomings connected with the use of this method. He states that the feeder method is out of date and that it should be replaced by a superior method. However, he does not make any suggestions which open up new prospects for a superior method.

Kalina studies the views expressed by a number of scientists in regard to the existence of genetic connections between bacteria and viruses. On this point, he cites work by N. F. Gamaleya, V. A. Krestovnikova, and G. M. Bosh'yan. Krestovnikova and Bosh'yan have actually presented experimental data which speak in

favor of the assumption that there is a genetic connection between bacteria and viruses, but much that has been done by them is not yet quite clear. Further investigations on this subject are necessary.

The theory of stage development of bacteria has been treated by Kalina all too briefly. It is not clear from his exposition whether he regards any filterable form of a microbe as a stage of the development of that microbe. It seems to us that although a filterable stage of microbes may be a regular stage of development, it may also be produced accidentally by the action of mechanical forces which bring about rupture and disintegration of the microbial cell. In both cases, the subsequent development will be similar: growth of secondary colonies from the filtrates will be observed. However, the biological meaning of the observed phenomena will be different.

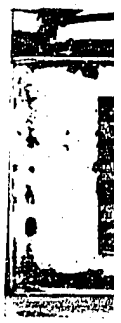
It is also difficult to agree with Kalina's statement to the effect that all forms of viruses must be genetically connected with microbes. The existence of noncellular organisms, the phylogenesis of which bears a precellular character and has no genetic relationship to any cellular forms, appears to be probable. One must assume that there existed in the past, and still exists, at present, a wide range of independent noncellular organisms. We are familiar with only a few representatives of this class of noncellular organisms, namely some parasitic (pathogenic) forms known as viruses.

Of great interest is Kalina's account of his attempts to induce a secondary growth in a chemically prepared nucleoproteid fraction of dysentery bacilli. He regards the results of one of his experiments along these lines as positive. In this particular experiment, transparent colonies developed around a ring-shaped colony of staphylococci which served as a feeder. After 1½ months of storage, the cultures in question acquired the capacity of being agglutinated with Flexner serum. Unfortunately, this result could not be reproduced when the experiment was repeated.

As can be seen from this account, Kalina's paper deals with questions which are of great importance to microbiology. In discussing these questions, he draws on his extensive experience as an experimental research scientist.

A. A. Imshenitskiy, in his article "On Problems of the Selection of Microorganisms" published in the same issue of Trudy Instituta Mikrobiologii, subjects to critical analysis the methods of selection which are applied in microbiology at present. He criticizes these methods from the standpoint of Michurinist biology. Among foreign microbiologists, the autogenetic approach to problems of the modifiability of microbes is still widespread. This approach is based on Morgan's chromosome theory of heredity. According to the views held by these microbiologists, modifications in microbes occur either spontaneously, i.e., independently of influences exerted by the environment, or under the strong action of physical or chemical agents. The environment and conditions of existence in general are relegated to the role of a factor which merely selects without actually instigating the processes leading to selection /i.e., the processes of modification/.

Rejecting these barren theories, Imshenitskiy demonstrates the validity and applicability of the fundamental postulates of Michurin's theory as far as the directed modification of higher organisms and the modifiability and heredity of microorganisms are concerned. He emphasizes that the basic method for obtaining new forms of microorganisms must consist of directed modification of microorganisms by changing the conditions of their existence. The experimental opportunities open to the microbiologist along these lines are almost unlimited, so that he is in a much more favorable position than selectionists who are working on higher plants or are breeding animals.



In principle, no objection can be made to Imshenitskiy's view that any physiological change must affect the structure of the cell. If one succeeds in establishing the existence of a correlation between the functional and morphological characteristics of a culture, and is able to observe the changes in question, selection of active varieties /literally races/ of microorganisms is facilitated. Imshenitskiy is right when he calls the attention of selectionists to the necessity of using such correlations in their work aiming at the selection of new strains which will prove more valuable in production. However, one must take into consideration that changes in the functional characteristics of cells, which have been achieved in the course of experimental work, are not always reflected in easily observable changes of the form of the cells, or of the form of the colonies which are composed of these cells. In some cases, modification of the internal structure of cells which are connected with functional changes are so insignificant that no practical use can be made of them in selecting the desired varieties of microorganisms.

Imshenitskiy gives many examples of directed modification of microorganisms and of gradual adaption of microorganisms to various physical factors, chemical substances, and new substrates. These examples are of undoubted interest to microbiologists who work on the directed modification and selection of microorganisms, because they demonstrate that successful results have already been achieved by microbiologists in this field. They also indicate the methods by which forms with a changed heredity have been obtained. In this connection, Imshenitskiy should have mentioned, for the sake of completeness, the following methods of directed modification and selection: cultivation on filtrates and preparations derived from related strains and application of sexual hybridization in the case of spore-forming yeasts.

In evaluating Imshenitskiy's article, one may say that it gives correct guidance to microbiologists in their work on the selection of those forms of microorganisms which will be of value for practical applications. It also will aid them in choosing appropriate methods for that purpose.

Additional Articles

The following articles were also published in Issue 1, Trudy Instituta Mikrobiologii: M. N. Meysel' and G. A. Medvedeva, "Against Perversion and Falsification by Morganists of the Cytology of Yeast Organisms;" V. I. Kudryavtsev, "Concerning the Problem of Species of Microorganisms;" D. L. Shamis, "Increase of the Fermentative Power of Wine Yeasts by the Method of Directed Training;" L. I. Komarova, "Selection of Yeasts Which Will Ferment Highly Concentrated Molasses;" N. A. Krasil'nikov, "The Biological Significance of Antibacterial Substances;" Ye. N. Mishustin, "Soil Bacteriology and Its Current Tasks;" and A. Ya. Musatova and S. I. Kuznetsova, "Regulation of the Productivity of Water Reservoirs by the Application of Biological Methods in Connection With the Introduction of Fertilizers."

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